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Soil Survey

of

Guthrie County, Iowa

By

C. L. ORRBEN, in Charge, and A. M. O'NEAL
Iowa Agricultural Experiment Station

and

A. H. HASTY and W. C. BOATRIGHT
United States Department of Agriculture

Bureau of Chemistry and Soils

In cooperation with the Iowa Agricultural Experiment Station

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SOIL SURVEY OF GUTHRIE COUNTY, IOWA

By C. L. ORRBEN, in Charge, and A. M. O'NEAL, Iowa Agricultural Experiment Station, and A. H. HASTY and W. C. BOATWRIGHT, United States Department of Agriculture

COUNTY SURVEYED

Guthrie County is in the west-central part of Iowa, in the fourth tier of counties east of Missouri River and in the fourth tier north of the State of Missouri. (Fig. 1.) A correction line gives the county an irregular shape. The total area is 595 square miles, or 380,800 acres. Guthrie Center, the county seat, is 50 miles west of Des Moines and about 100 miles northeast of Omaha, Nebr.

Topographically Guthrie County is sharply divided into two parts, the dividing line closely following the east bank of Middle Raccoon River. That part lying northeast of the river has a characteristic constructional relief due to glacial deposition, and the part lying southwest of the river has a characteristic destructional relief due to the development of an erosion cycle, now in submature development, on a smooth plain.

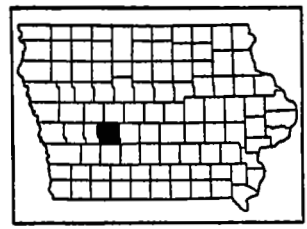

FIGURE 1.—Sketch map showing location of Guthrie County, Iowa

The area having a constructional relief is predominantly smooth, broken by low rounded swells or elongated ridges. Interspersed between the swells are broad, flat, originally marshy areas. Small ponds or saucer-shaped basins dot the plain. Mosquito Creek and Bays Branch meander sluggishly over wide basins with indefinite channels, the water in many places spreading over wide areas and forming shallow lakes or marshy bogs. The tributaries of these streams are short and undeveloped. Near Middle Raccoon River, however, the relief is more broken. The slopes are steep, and valleys have been cut a short distance into the uplands. The area as a whole has been but slightly affected by stream action.

In sharp contrast to this immature development is the rugged relief of that part of the county southwest of the river, where the surface features are the product of erosion. Here, the entire area has been reduced from a level plain underlain by drift of the Kansan epoch to a thoroughly dissected area. The large streams have well-developed tributaries which are fed by numerous smaller streams, forming a drainage system which thoroughly drains the area. The slopes range from gentle near the smaller tributaries to steep or abrupt near the large valleys.

A narrow divide separates the tributaries of the Mississippi River drainage system from those of the Missouri River system. The county is drained mainly by the tributaries of Raccoon River, which

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flows into Des Moines River, the latter flowing into Mississippi River. A small part of the southwestern corner of the county is drained by the Missouri River system.

Elevations and the direction of stream flow indicate that the slope is to the east and south. Bayard, located near the western border of the Wisconsin drift area, is at an elevation of 1,134 feet [1] above sea level. The elevation at Jamaica in the northeastern corner of the county is 1,042 feet. Other elevations within the county are 1,077 feet at Guthrie Center, 1,228 feet at Casey on the divide between the two drainage systems, 1,264 feet at Menlo, and 1,207 feet at Stuart. The highest point in the county is at Adair in the southwestern part, where the elevation is 1,403 feet above sea level.

The original prairie grass (bluestem) has been almost entirely replaced by bluegrass, white clover, and various weeds. Native trees, including mainly oaks, elm, hickory, ash, walnut, cottonwood, willow, and haw, cover a large part of the hilly land along the larger streams. Hazel brush and buck brush, together with berry bushes, are constantly invading the hillsides utilized as permanent pastures. The low poorly drained terraces and bottom lands support a heavy growth of slough grass. The better-drained first bottoms are lightly forested and support an undercover of bluegrass and various weeds.

The first white settler's home was built in Jackson Township along South Raccoon River in 1848. Three years later the county was organized, with the county seat located at Panora. The population at that time was 222 persons. In 1859 the county seat was moved to Guthrie Center, in 1861 was moved back to Panora, and in 1873 was permanently located at Guthrie Center.

The majority of settlers came from the Eastern and Southern States, and people of foreign extraction came from Germany, Ireland, and the Scandinavian countries. At present the population consists almost entirely of native-born whites. The 1930 census [2] records the population as 17,324 persons, all of whom are classed as rural. The census classes 10,131 as rural-farm and 7,193 as rural-nonfarm population. Guthrie Center has a population of 1,813. Other towns of importance are Panora, Stuart, Menlo, Casey, Jamaica, Bayard, Bagley, and Yale.

The Chicago, Milwaukee, St. Paul & Pacific Railroad serves the northern part of the county, and the Chicago, Rock Island & Pacific Railway the southern part. All the larger towns are located either on one or the other of these railroads.

Public highways follow land lines wherever possible. Steep grades are avoided by following the ridges or stream courses. Two State primary roads are now being graded and paved. These roads will connect Guthrie Center and several of the other towns by hard roads. United States Highway No. 32 traverses the extreme

[1] GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bul. 274, Ed. 4, 1072 p. 1906.

[2] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

southern part of the county, serving as a direct route between Des Moines and Omaha, Nebr. The secondary-road system is maintained by the county. These roads are of earth construction, well graded, and dragged.

Rural schools are located at regular 2-mile intervals. All the towns maintain accredited well-equipped high schools. Two consolidated district schools within the county are located at Bayard and Menlo.

Practically all homes have telephones and radios, and rural mail service reaches all parts of the county. High-tension lines furnish some farms with electricity for power and lighting purposes.

Because of the automobile and good roads, the small country church is rapidly losing in favor, and the town churches are replacing many of the old meetinghouses.

The industries of Guthrie County are primarily agricultural. A few small coal mines furnish local communities with fuel. The largest mine is located near Fanslers, from which coal is transported to the neighboring towns and farms.

Livestock and surplus grain are marketed in Chicago and Omaha. Minor farm products, as butter, eggs, and poultry, are bought up by local buyers who ship such products in car lots to eastern markets.

CLIMATE

The climate of Guthrie County is continental and typical of the Corn Belt region. It is favorable for the production of all the staple crops common to the State. It is marked by wide variations in seasonal temperatures, ranging from a mean summer temperature of 71.9° F. to a mean winter temperature of 21.5°. Extreme temperatures, as recorded by the Weather Bureau station at Guthrie Center, range from −35° in January to 107° F. in both July and August. The spring and fall months are warm and pleasant. About two-thirds of the annual rainfall occurs during the growing season in the form of showers, often accompanied by lightning and high winds. Most of the precipitation during the winter is in the form of snow. Damage by hail is generally limited to small areas in the path of the storm. Rains during November and December hinder the gathering of the corn crop in some years. Droughts of extended duration are uncommon, although July and August are generally very hot and dry, but light showers during these months prevent firing of the crops. Southerly winds predominate during the growing season and northerly winds in the winter months.

The average frost-free season extends over a period of 154 days, from May 3 to October 4. Frosts have been recorded as late as May 31 and as early as September 12, but the very early and very late frosts, as a rule, are not damaging to crops. The grazing season extends over a period of about 200 days.

The normal monthly, seasonal, and annual temperature and precipitation as recorded at Guthrie Center are given in Table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Guthrie Center, Iowa*

[Elevation, 1,077 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1901)	Total amount for the wettest year (1919)	Snow, average depth
	°F.	°F	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	23 9	63	−29	1 11	0 79	0.63	6.8
January	18.5	60	−35	.78	1.10	.02	5 5
February	22.0	71	−32	1 11	75	2 92	6 2
Winter	21 5	71	−35	3 00	2.64	3.57	18.5
March	34 7	87	−15	1 50	1 55	2.61	5 5
April	49 1	95	11	3 13	2.02	6 04	.8
May	60 6	95	19	4 70	95	2.69	(1)
Spring	48.1	95	−15	9.33	4.52	11 34	6 3
June	69 7	100	35	4 46	4 74	8 55	0
July	74.1	107	40	4.22	1 76	3 42	0
August	71 9	107	36	3.86	1 25	1 42	0
Summer	71 9	107	35	12.54	7 75	13 39	0
September	64 6	100	19	3 77	4 17	9 44	0
October	51.1	89	9	2 66	2.15	4 53	.5
November	36 3	79	−8	1 45	1 33	3 26	2.4
Fall	50 7	100	−8	7 88	7 65	17 23	2 9
Year	48.0	107	−35	32.75	22.56	45 53	27.7

[1] Trace

AGRICULTURE

Agriculture has been the primary industry in Guthrie County since the time it was founded. The early settlers produced sufficient grain and garden produce to supply the home needs, and the meat supply was obtained by hunting and fishing. The few head of livestock owned were allowed to roam the wooded land and the prairies. Furs served as the trading commodity in exchange for the necessities not produced on the farms. The streams furnished a means of transportation for marketing the small quantity of surplus produce. With the advent of the railroads, settlement of the county progressed rapidly, and the production of corn, wheat, and other produce was begun on a large scale.

General farming is centered around the production of corn, oats, and hay and the raising or feeding of sufficient livestock to consume most of this feed. Corn occupies the largest acreage, averaging about 100,000 acres annually. Oats follow in importance, with approximately one-half as large an acreage as the corn crop. The hay acreage varies somewhat with the prices of the grain crops, and when grain prices are high some of the hay meadows are plowed and used for grain production. In the early development of the

agriculture of the county, wheat was an important crop, second only to corn. After 1900, the acreage devoted to wheat diminished rapidly, and, with the exception of the period during the World War, wheat has since been a minor crop.

Table 2 gives the acreage and production of the principal crops grown in Guthrie County in six census years.

TABLE 2.—*Acreage and production of the principal crops in Guthrie County, Iowa, in stated years*

Year	Corn		Oats		Wheat		Hay	
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Tons*
1929	112,453	4,191,684	56,944	1,775,899	2,480	51,676	32,852	51,970
1919	110,267	4,768,458	54,465	1,782,009	15,336	203,945	29,205	43,101
1909	99,603	3,553,783	43,541	1,088,771	3,404	42,590	48,274	72,500
1899	111,710	4,663,560	53,800	1,967,230	15,142	229,950	42,803	59,642
1889	93,773	3,846,831	48,698	1,979,131	4,055	49,074	43,352	57,171
1879	72,599	2,985,347	8,855	281,710	27,736	290,515	14,898	25,113

The greater part of the grain produced on the farms is fed to cattle, hogs, and sheep. Some grain is sold from crop-share and cash-rented farms and also from the large corn-producing farms in the level section of the county east of Middle Raccoon River.

Hog raising is the principal livestock industry, and every farmer raises hogs, the number depending on the supply of feed. The 1930 census records the number of hogs in the county on April 1, 1930, as 88,821. The greater numbers of hogs are raised in the northeastern part mainly because of the greater acreage in corn. Dairy cattle are kept on all farms, although the largest numbers are kept in the hilly sections where pasture land is plentiful. Cream and milk are marketed locally at the creameries or produce stations. The feeding of beef cattle has been an important industry in the past but at present meets with some disfavor. Western feeder lambs are pastured on hilly land and fattened on corn and small grain. Horses furnish most of the farm power, and a few colts are raised to replace the older horses or for sale.

The use of fertilizers, other than manures, is unusual. The expenditure for commercial fertilizer, including lime, in 1929 on the 77 farms reporting its use was $3,699, or an average of $48.04 a farm. Commercial fertilizers, mainly phosphates, are tried on small plots, and when they prove profitable are used on a larger scale. The census reports 123 tons purchased in 1929.

Most of the farm labor is performed by the farmer and his family, but during planting and harvesting seasons extra labor is often required, this being supplied from the local towns. Day laborers receive from $2 to $4; when hired on the monthly basis, the wages range from $45 to $55, with board and room furnished; and laborers hired by the year receive from $40 to $50 a month.

Table 3 shows the average size, number, value, area, and tenure of farms as reported by the census for the period 1880 to 1930.

TABLE 3.—*Number, size, value, area, and tenure of farms in Guthrie County, Iowa, in census years*

Year	Farms	Average size of farms	Land value per acre	Area of county in farms	Farms operated by—		
					Owners	Tenants	Managers
	Number	*Acres*	*Dollars*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1930	2,379	151 9	97 95	94 9	49 7	49 4	0 9
1920	2,315	154 6	195 08	94 0	56 0	42 7	1.3
1910	2,330	152 0	84 06	93 0	57 6	41 8	6
1900	2,492	143 3	31 37	93 7	60 6	38 6	.8
1890	2,248	145 0	.....	85 5	67 9	32 1	.....
1880	1,722	130 0	.....	58 7	71 3	28 7	.....

Farms are well equipped with modern farm machinery for planting, cultivating, and harvesting the crops. Tractors are used on some of the level farms, but as a rule horses and mules furnish the farm power. The water supply is pumped from wells by windmills or small engines. The farm buildings are conveniently located, surrounded by windbreaks, and arranged so that feeding and caring for the livestock requires as little time as possible. Dairy farmers and some feeders of beef cattle have silos near the barns and feed lots.

The surface relief of approximately 75 per cent of Guthrie County ranges from rolling to strongly rolling or hilly. Cultivable areas in the hilly sections are confined to the ridges and smooth or gentle slopes, and the remainder of the land is used as hay or pasture land; therefore the type of farming followed must include some means of utilizing the extensive pasture areas, and the farmers have naturally adopted the cattle industries. The remaining 25 per cent of the county lies east of Middle Raccoon River, where the relief is undulating, and broad level areas of rich prairie land are ideal for the production of corn and small grains. Approximately all this land is under cultivation. Most of the farmers in this section are grain farmers, the crops are sold for cash, and less livestock is raised or fed than in any other part of the county.

The cattle industry is twofold in character. Individual preference and facilities for caring for the livestock generally determine whether dairying or the feeding of beef cattle will be adopted. These two phases of the cattle industry are equally important in Guthrie County. Dairying is of greatest importance in the western, northwestern, and southern parts, and the feeding of beef cattle prevails in the section extending diagonally southeast from Bayard to the center of the county and in Bear Grove Township in the western part.

The dairy industry has been prominent for a number of years. Each farm maintains a herd of good grade milk cows, the number depending on the pasture acreage, the amount of hay available for roughage, and the supply of grain produced on the tillable areas of the farm. Herds range in size from 5 to 30 head. The breeds preferred are Holstein-Friesian, Brown Swiss, Jersey, and Guernsey. Most farms are not equipped to care for more than 10 or 15 milk cows, and under these conditions, milking is done by hand, the milk separated, the cream sold at the creameries, and the skim milk fed to

hogs The larger dairy farms have modern barns, silos, and milking machines to facilitate the handling of the product. Local produce houses and cooperative creameries serve as an outlet for the cream and milk supply. A few creameries maintain regular routes, collecting cream twice weekly in the winter and three or more times a week during the hot summer months.

The Iowa Yearbook for 1925 reports the amount of cream received at the six creameries reporting within the county at 1,859,460 pounds, from which 741,854 pounds of butter were manufactured. The value of the butter was $262,393. This does not include the entire amount of dairy products produced in the county, as creameries located in adjoining counties receive a large amount of cream, and produce stations in all the towns collect cream and ship the supply to larger creameries in the cities. It is estimated that the value of dairy products in Guthrie County exceeds $500,000 annually.

A few beef cattle are raised within the county, but the majority are purchased as feeders on the Omaha, Denver, and Sioux City markets, or direct from the ranges of Nebraska, and shipped into the county in carload lots. Young feeders are preferred. The animals are pastured and placed on light feed immediately and when they attain sufficient size are placed on a heavy finishing ration. Feeding operations extend over a period ranging from 150 to 220 days When finished, the cattle are sold at Chicago, Omaha, or St. Joseph.

Shorthorns, Herefords, and Angus rank in number in the order named. Many grades and crosses of these breeds are fed, but the experienced feeders of beef cattle prefer the better grades of the various breeds because the cattle finish out more evenly and bring higher prices on the market.

Many farmers prefer beef cattle because they require less care than dairy cattle. The average number of beef cattle of all breeds fed and sold annually is approximately 35,000. Market values and crop yields greatly influence the annual extent of the cattle industry.

Hog raising is practiced on almost every farm. The smallest numbers are raised in the cash-grain section east of Middle Raccoon River. Hog raising generally is carried on in connection with the cattle industries. Dairymen raise large numbers of hogs to consume the skim milk produced, and beef-cattle feeders allow the hogs to follow the cattle in the feed lots, thus avoiding considerable waste. The fattened animals are sold on the Chicago and Omaha markets.

Brood sows are selected from the herd and bred to a purebred or good grade sire. A recent practice adopted by many hog raisers is to cross breeds. By this method a type of hog is produced that gives greater returns as the packers prefer the animals of mixed breeding. Duroc-Jersey, Hampshire, Poland China, and Tamworth are the favorite breeds.

Sheep raising is of slight importance. A few head are kept on some farms to aid in keeping down the brush in pastures and to clean out weeds in permanent pastures and fields. Less than 6,000 head are kept on the farms annually.

From 4 to 10 horses or mules a farm are needed as work animals, the number depending on the amount of tillable land and the size of the farm.

The value of poultry (which includes chickens, ducks, geese, and turkeys) raised in Guthrie County in 1929 was $387,393, and the value of chicken eggs produced was $455,386. Every farmer raises chickens as a side line. Eggs and live poultry are marketed at stores, traded for groceries, or sold for cash at local produce houses. Trucks sent out by different firms tour the rural districts, collecting eggs and poultry, which are concentrated at a central market and shipped in car lots to the eastern markets, or are hauled to Chicago on large motor trucks.

SOILS AND CROPS

Guthrie County lies within the corn-producing section of the United States. Corn is the major crop, and the agriculture of the county is based on its production. The value of the land is largely determined by its ability to produce high yields of corn economically over large acreages, with the use of labor-saving machinery. Climatic conditions are uniform over the county, therefore are of no consequence as affecting differences in crop yields or in the systems of farming or cropping. However, there are marked differences in crop yields and systems of farming in different parts of the county because of soil differences which are due to the character of the parent material and to the effect of erosion.

The northeastern part of the county lies within the Wisconsin drift area, and the soils are derived entirely from glacial débris. The surface relief ranges from level to undulating, except near the larger streams where the relief is more pronounced. Soil-forming processes progressed under good or poor drainage conditions in different areas, and the soils as they are to-day are the final result of these weathering processes. The level or undulating surface was ideal for the accumulation of great quantities of organic matter, as evidenced by the predominantly dark color of the soils. Corn is grown in this part of the county as a cash crop, therefore it must be produced at a minimum cost. The level extensive areas of cornland, regular-shaped fields, and naturally fertile soils combine to make this an ideal corn-growing section. Power and labor-saving machinery can be utilized to advantage, thereby making it possible for one man to care for a large acreage with a resultant low cost of production.

The remainder of the county, or that part south and west of Middle Raccoon River, presents entirely different topographical conditions. The surface relief ranges from rolling to hilly. With the exception of a few level areas in the southeastern part of the county, farming operations must be conducted on narrow ridges and slopes. The depth of the silty covering has been greatly altered by erosion, and in many places this material has been entirely removed and the underlying gritty clay glacial till exposed. Large acreages of forested, brush-covered, and untillable land, which serve as permanent pastures, are common in this section of the county. The chief source of income is from the sale of dairy products, beef cattle, and hogs. Feed for the livestock is grown on the ridges and upper slopes, and hay for winter roughage is grown on slightly steeper slopes and at the bases of the cropped slopes. The noncultivable areas serve as pastures throughout the grazing season. Corn and small-grain land is therefore limited, and many of the fields are small and irregular in size and shape.

Corn is the dominant crop over the county; it is grown wherever possible and as often as possible without depleting the soil fertility to such an extent that crop yields will be materially lowered. Erosion serves as a check to the amount of land that may be planted to corn. Many fields formerly planted to this crop have become so badly eroded that owners have been forced to seed them down to meadows. Others have been cropped so long and washed so badly that not even bluegrass can obtain a foothold. Deep ditches and gullies have cut back into the uplands, destroying the slopes even for pasture purposes.

The ability of the different soils of the county to produce corn differs markedly. As a rule, the dark-colored soils, such as Webster silty clay loam, Clarion loam, Carrington loam, Tama silt loam, and Grundy silt loam when properly drained, are the best corn soils because they are high in organic matter and are naturally productive. Differences in the yields received from each individual soil are in part due to the methods of handling and the cropping systems used by the different farmers. Owner-operated farms are, as a rule, the better managed and, therefore, higher producers. Under the prevailing rental system the incentive to improve the land is lacking, and unless long-term leases are adopted improvement of the land holds but little advantage to the renter.

Approximately one-third of the area of the county is annually devoted to corn. The 1925 Iowa Yearbook reported corn grown on 115,608 acres with a total grain production of 3,144,538 bushels, or an average of 27 bushels an acre. The yields on the different soil types, according to farmers' estimates, range from 85 bushels an acre on the well-drained heavy black land to about 15 bushels on light-colored cleared woodland and steep slopes. Preparation of the land for corn, cultivation, and harvesting of the crop are performed similarly throughout the county. Plowing is done either in the spring or fall, and disking and harrowing precede the spring planting. Cultivation begins as soon as the corn is planted and continues until the plants may be injured by the horses or machinery. A few mechanical pickers are used in the larger fields but, as a rule, harvesting is done by hand. About 90 per cent of the corn grown is harvested for the grain, and the rest is either hogged down or cut for silage.

Corn is grown as a cash crop in the northeastern part of the county, but in the remainder of the county all the grain produced is fed on the farm. The cash corn is marketed at local grain elevators or trucked to the dairy and beef cattle sections.

When it is necessary to supplement corn with other crops to prevent soil depletion, small grains and hay are grown. Oats rank second to corn in importance. They fit into the rotation well, can be seeded and harvested when other crops do not require attention, and serve as an excellent nurse crop for the clover, alfalfa, and timothy hay crops. The grain is used as feed for work animals or ground and fed to dairy cattle and hogs. Most of the soils of the county are suitable for the production of oats, but on many areas of Webster silty clay loam oats have a tendency to produce a rank straw growth, causing the plants to lodge badly. With the development of stiff-strawed varieties this defect can be minimized. Oats are best suited to the lighter-textured soils, such as Carrington loam, Clarion loam, Tama silt loam, and Grundy silt loam.

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Wheat is sometimes grown as a cash crop. The winter varieties are preferred, as they yield better than the spring wheats. Although wheat was a major crop two decades ago, the annual acreage at the present time is only about 3,000 acres. Yields range from 10 to 30 bushels an acre, the higher yields being obtained on the well-drained dark-colored soils of the county. The grain is sold at local elevators.

The production of barley has been adopted in many communities and is growing more in favor each year. It can be grown where such cultivated crops as corn can not be grown without causing serious erosion in the fields. Barley serves as a very good nurse crop for clover and timothy. The grain is used as a supplement to corn in the feeding ration and is available for use in late summer or early fall. Hogs can be started on barley and finished on corn as soon as it matures in the fall. Practically all the cultivable soils, except the poorly drained heavy soils, are suitable for growing barley.

The hay crop consists mainly of a mixture of timothy and clover. The acreages of alfalfa and sweetclover are small. More than 80 per cent of the surface soils of the county are acid and require applications of limestone before alfalfa or sweetclover can be successfully grown. Timothy and clover meadows are generally located on hillsides which are more or less subject to erosion under cultivation. Hay is cut from these meadows for two or three years, after which the fields are pastured until the stand thins out and weeds become too abundant. The 1930 census reports the total hay land in 1929 at 32,852 acres, on most of which was grown a mixture of timothy and clover. Clover and timothy seed are produced to supply the needs of the farm, and any surplus seed is sold locally to neighbors or at the grain elevators.

Land devoted to special crops is confined to home gardens, as the lack of markets prevents extensive specialization in Guthrie County.

The value of land is greatly influenced by the type or types of soil occurring on the farm, the surface relief, and the amount of cultivable land available for crops. Those farms consisting of well-drained naturally fertile soils, practically all of which can be cropped, are much more valuable than farms consisting mainly of hilly partly wooded pasture land. A mellow loam or silt loam soil, heavily impregnated with organic matter, and therefore dark colored, well drained, and well located, is an ideal corn soil. With corn as the dominant crop, any land suitable for its production on a large scale is highly prized. Small grains and hay can be grown on more hilly land where cultivated crops, such as corn, may cause damage through erosion, and consequently the small-grain acreage is not so limited as cornland. Most farms include two or three different soil types, and in discussing the various soil types in the county a grouping of the soils on their agricultural value may be made on the basis of their cropping value as compared with the major crop, corn.

The soils of Guthrie County, on the basis of use, may be divided into three groups as follows: (1) Soils used mainly for grain, (2) soils used for grain and pasture, and (3) soils used for pasture.

In the following pages of this report the soils of Guthrie County are described in detail, and their agricultural uses and possibilities are discussed; their location and distribution are shown on the

accompanying soil map; and their acreage and proportionate extent are given in Table 4.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in Guthrie County, Iowa*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Tama silt loam	49,280	12.9	Clarion fine sandy loam	1,216	0.3
Marshall silt loam	896	.2	Dickinson fine sandy loam	192	.1
Grundy silt loam	4,800	1.3	Bremer silty clay loam	832	.2
Carrington loam	40,576	10.7	Fargo silty clay loam	2,496	.7
Clarion loam	14,464	3.8	Wabash silt loam, colluvial phase	768	.2
Webster silty clay loam	22,464	5.9	Clarion loam, steep phase	512	.1
Webster loam	1,856	.5	Lindley loam	4,736	1.2
Waukesha silt loam	6,592	1.7	Crawford loam	576	.2
Judson silt loam	4,416	1.2	Wabash silt loam	32,192	8.5
Bremer silt loam	6,848	1.8	Wabash silty clay loam	4,736	1.2
O'Neill loam	1,024	.3	Wabash loam	2,432	.6
O'Neill fine sandy loam	1,024	.3	Peat and muck	128	.1
Shelby loam	98,496	25.8			
Clinton silt loam	2,816	.7	Total	380,800	
Tama silt loam, shallow phase	74,432	19.5			

SOILS USED MAINLY FOR GRAIN

This group of soils includes soils of high natural productivity, which are well drained both in the surface soil and subsoil and have a surface relief which allows easy cultivation of extensive areas. The soils placed in this group are Tama silt loam, Grundy silt loam, Carrington loam, Marshall silt loam, Clarion loam, Webster silty clay loam, Webster loam, Waukesha silt loam, Judson silt loam, Bremer silt loam, O'Neill loam, and O'Neill fine sandy loam.

Tama silt loam.—Tama silt loam is commonly known as the dark rolling prairie soil. The surface material, to a depth of about 12 or 15 inches, is dark grayish-brown friable silt loam which when wet is very dark brown or almost black. Below a depth of 15 inches the dark organic coloring begins to disappear, and at a depth of about 24 inches the heavy silt loam subsoil is brown or yellowish brown. Dark-brown streaks from the upper layers give the mass the brown color. Beneath this heavy silt loam is pale yellowish-brown smooth even-textured silt loam, throughout which streaks and stains of brown, rust brown, and black are common. No lime carbonate is present in the soil profile to a depth of 75 inches.

Tama silt loam is one of the best corn soils in that part of the county west and south of Middle Raccoon River. It requires good management to keep it on a high-producing level; therefore most of it is placed under a definite cropping system which includes a legume. Corn is grown for two years, after which the land is seeded to oats, wheat, or barley. The small grain serves as a nurse crop for the meadow seeding which generally consists of a mixture of timothy and clover. The fields are allowed to remain in meadow three or four years. Hay is cut for the first two years, and then the meadows are pastured until the timothy and clover stands thin out to such an extent as to be unprofitable. Tama silt loam occurring on less gentle slopes can not be plowed so often as that on the smooth slopes, without causing damage through erosion. The sloping areas are therefore allowed to remain in hay and pasture for longer periods, and when they are plowed only one crop of corn is pro-

duced and the fields are immediately seeded down and left in pasture for an extended time.

Other soils closely associated with Tama silt loam occur on most farms. Most areas of the associated soils are too steep to cultivate, but they support an excellent stand of bluegrass and other pasture grasses. As practically all farms include different acreages of all the crop soils, they are especially adapted to the cattle industries. Corn and small grains can be grown on the tillable land, hay for winter roughage can be grown on the more rolling areas, and the steep eroded slopes serve as good grazing land. Either the dairy or beef cattle industry is adopted, depending on the facilities or preferences of the individual farmer.

The yields of the different crops on Tama silt loam differ on individual farms, according to the management of the land. A large part of Tama silt loam is operated by tenant farmers. Owner-operated farms are almost invariably more systematically managed and therefore produce higher yields of the grain crops. Farmers' estimates of corn yields range from 20 bushels an acre on run-down land to 75 bushels on well-managed farms on which rotation of crops is practiced. Yields of small grains and hay vary in much the same proportion as yields of corn.

Tama silt loam responds readily to various treatments. The surface relief ranges from rolling to strongly rolling, and care must be taken to prevent washing of the surface material from the slopes and narrow ridges. This soil is acid in reaction in both surface soil and subsoil; therefore liming is necessary for the best growth of legumes. Commercial fertilizers, especially phosphates, when applied to cornland previously in clover, produce marked increases in the yield. By keeping Tama silt loam well supplied with organic matter, by making regular applications of both green and farm-yard manure, and by rotating the crops, crop yields can be maintained at a high level. Tama silt loam becomes low in fertility very rapidly under poor management, because of the rolling relief and the effects of leaching and surface run-off, which carry away large quantities of plant food.

Marshall silt loam.—A few small areas of Marshall silt loam occur in the northwestern corner of the county. This soil differs from Tama silt loam principally in the lime content of its subsoil. The surface soil and upper subsoil layers can not be distinguished from the corresponding layers of Tama silt loam, as no lime can be detected, but the lower subsoil layer contains a considerable quantity of lime. On the more level areas, where leaching has gone on in undisturbed soil for a long time, lime lies at a depth of several feet. On slopes, over which the greater part of this soil occurs in Guthrie County, the leached surface soil has been removed rapidly by erosion and the lime is nearer the surface. Over much of the area, lime is within 2 feet of the surface and, in places, within a few inches.

The crops grown on this soil and the yields obtained do not differ widely from those on areas of Tama silt loam having a similar range of relief. The soil is particularly well adapted to sweetclover and alfalfa because of the excellent natural drainage and of the lime in the subsoil, and good stands of these crops are often obtained without liming. Sometimes liming is necessary to insure a stand of

these legumes if the surface soil is acid in reaction, and inoculation is necessary when the same crop has not been grown previously on the land. The average yield of corn is estimated to be about 43 bushels an acre, but, under careful cultivation, much higher average yields are obtained on the better land. A large part of this soil occurs on slopes so steep that washing and gullying takes place if the land is cultivated. Such hillsides are used principally for hay land or pasture.

Grundy silt loam.—The divide followed by the Chicago, Rock Island & Pacific Railway, from Stuart west to Casey, is broad and level in many places. These level areas have decidedly different subsoils from those of the rolling Tama silt loam, and they have been classified as Grundy silt loam. The surface soil to an average depth of about 15 inches is very dark grayish-brown friable silt loam. The color is almost black when the soil is wet. Between depths of 15 and 20 inches the color becomes more brown and the texture changes to heavy silt loam. Some dark organic-matter coloring is present. Beneath a depth of 20 inches and extending to a depth of about 30 inches the material is gray and drab silty clay which is decidedly heavier in texture than any of the overlying materials. A few dark streaks penetrate this layer. The lower part of the subsoil is mottled gray and brown clay loam containing numerous mottles of rust-brown and black iron stains. In a pit dug along the highway 1½ miles east of Menlo, the water table lies at a depth of 59 inches.

Grundy silt loam is naturally fertile, but in many of the more extensive areas it is necessary to use artificial drainage before maximum crop yields can be obtained under all seasonal conditions. This is the only soil within the loessial area which is not subject to erosion. The level surface relief prevents the run-off of surplus water, and the heavy subsoil hinders its passage through and escape into the lower horizons.

Grundy silt loam is highly prized as cornland and is used for corn as often as possible. Wheat and oats are used to supplement the corn, but the fields are seldom seeded down to a legume-hay crop. Other land not suitable for corn growing occurs on the same farms, therefore farmers must take advantage of the tillable land for the grain crops. The result of this arrangement is the almost continuous cropping of the level areas and a consequent depletion of their soil fertility. Very few farms are composed entirely of Grundy silt loam. It is closely associated with Tama silt loam, the latter soil everywhere surrounding it.

All grain crops grow well on Grundy silt loam. The yields obtained are slightly higher than on Tama silt loam, corn yields averaging about 45 bushels an acre, with yields ranging from 30 to 80 bushels on different farms.

Although crop yields are consistently high on Grundy silt loam, better yields are certain if the wet areas are drained and the fields placed under a regular cropping system. Applications of barnyard manure and the plowing under of a clover crop would materially enrich the soil which is acid in reaction. Liming is necessary, especially for legumes, such as sweetclover and alfalfa.

Carrington loam.—Carrington loam is the most extensively developed soil in the drift area, or that part of the county east of Middle

Raccoon River. It covers approximately one-half of this section of the county. The surface soil is very dark grayish-brown loam 12 or 14 inches thick. The comparatively high content of organic matter imparts to the soil its dark color. The presence of sand and fine sand gives the soil mass a friable texture and allows greater ease in handling under adverse moisture conditions than the heavier-textured soils, such as silt loams and silty clay loams. Beneath the surface layer and continuing to a depth of about 30 inches is yellowish-brown sandy clay loam, the upper part of which is decidedly darker than the lower part. Dark organic material from the upper layer has filtered into this layer, gaining entrance through animal burrows, wormholes, or root channels. Many small bowlders are embedded in the upper part of the subsoil. The texture of this layer, although much heavier than that of the surface soil, is porous enough to allow excess water to percolate through. Below a depth of 30 inches the subsoil material changes to bright yellowish-brown gritty sandy clay loam. No lime is present to a depth of 50 inches, but below this calcareous material is abundant in most places.

Carrington loam is naturally one of the best-drained soils of the drift area. The undulating relief and the gritty texture of the subsoil aid materially in the escape of surplus moisture following rains. The soil warms up early in the spring, responds quickly to fertilizer treatment and good management, and is, therefore, highly prized as cornland.

Cornland in this section of the county is more plentiful than in the loessial section, because of the level surface relief. Practically all the land can be placed under the plow and cropped. Under these circumstances it is not necessary to grow corn continuously on one field for a series of years, and the productiveness of the land is less apt to run down. Crop yields are, therefore, higher than on Tama silt loam. Corn yields often reach a maximum of 85 or 90 bushels an acre on the best farms. However, these yields are not average for this section, owing to the type of farming followed. Most of this soil is within the cash-grain area, and few farms maintain sufficiently large herds of livestock to consume the feed produced. Because the grain is sold, the supply of manure is very small, and the growing of clover for green manure is limited, the fertility of this soil has been depleted on many farms. According to estimates obtained from farmers in this section of the county, Carrington loam will produce an average yield between 45 and 50 bushels of corn an acre, with other grain crops in proportion.

Clarion loam.—Clarion loam is closely associated with Carrington loam. It is very similar to Carrington loam, except that lime is present in the subsoil of Clarion loam. The surface soil is very dark grayish-brown loam which appears almost black when wet. The depth of the dark layer is greater and the texture slightly heavier than in Carrington loam, but the soil is still a loam. The subsoils of these two soils differ in that the Clarion loam subsoil has more yellow coloring. Free lim eis present in sufficient quantities to impart the light-yellow color to the subsoil at a depth ranging from 24 to 28 inches. Natural drainage is good, owing to the undulating relief and the gritty subsoil. Crop yields on Clarion loam are about the same as those obtained on Carrington loam. Clarion soils are

better adapted to growing sweetclover and alfalfa because of the presence of lime throughout the subsoil.

Webster silty clay loam.—Webster silty clay loam is one of the most important soils of this group. The areas are extensive, and when the land is properly drained no other soil in the county is able to surpass it in crop-producing power. The deep dark silty clay surface soil is heavily impregnated with humus to a depth ranging from 12 to 16 inches. The subsoil is gray gritty clay loam thoroughly filled with lime. Granitic and limestone bowlders are embedded throughout the subsoil.

Webster silty clay loam occupies the broad flat plains or saucer-shaped basins, either separate or interlocking one with the other, and extending in a continuous chain for several miles, wide in one place and narrowing to a few hundred feet in another. Small knolls rise above the general level of the large areas.

Before these large flats, or sloughs as they are locally termed, were drained, they were covered by water during almost the entire year. Water-loving plants grew luxuriantly, died down each year, accumulated, and partly decayed. This organic material has given rise to the thin layer of peat and muck so common on these flat areas.

Most of the area of Webster silty clay loam has been under cultivation for a shorter period than the naturally drained soils of this section of the county. It is the youngest farming soil and also the most fertile. It is one of the best corn soils in the State, if properly drained, and will withstand continuous cropping to corn for longer periods, without any noticeable harmful effect, than any other soil in the county Corn, therefore, is grown as often as possible on this rich dark soil, and the yields average between 45 and 50 bushels an acre. Small grains tend to make too rank a growth of the straw, and they lodge badly when grown on Webster silty clay loam. Some of the stiff-strawed varieties of winter wheat can be grown successfully and are used in rotation with the corn crop at regular intervals.

Webster silty clay loam is heavy in texture, is sticky when wet, and has a tendency to crack badly on the surface when dry. This last-mentioned characteristic causes some damage to small grains when they are planted in the fall, but the cracking has little or no effect on the corn crop. If the fields are plowed while wet, the soil clods to a great extent, but in a short time the clods readily crumble and fall apart. The surface soil may or may not contain lime, but the subsoil is everywhere very calcareous.

Webster loam.—Webster loam occupies a slightly higher position than Webster silty clay loam and is naturally better drained. The presence of considerable sand and fine sand in the surface layer of this soil makes it easier to handle than the silty clay loam. It plows easier, warms up earlier in the spring, and clods less than the silty clay loam, when plowed or worked under adverse moisture conditions. Webster loam is a very good corn soil and is adapted to the growing of small grains. It is generally placed under a definite cropping system similar to that employed on Carrington loam and Clarion loam.

Waukesha silt loam.—Waukesha silt loam occurs on high terraces, well above overflow, is well drained, and is fertile. The parent material, from which this soil was derived, was eroded from the

uplands and deposited on the then flood plains of the stream. As the stream channel was cut down to its present level these old first bottoms were left above overflow and now exist as terraces. This soil is mapped along all the larger streams of the county, but the total area is not large. The surface soil is very dark grayish-brown mellow silt loam overlying yellowish-brown heavy silt loam or light silty clay loam. The lower part of the subsoil becomes more yellow in color and the texture more silty with depth. Although the terraces occupied by this soil are level, the friable subsoil allows the excess water readily to percolate through, affording good drainage of both the surface soil and the lower layers.

Waukesha silt loam is of about the same fertility as Tama silt loam of the uplands. It is generally farmed in conjunction with some upland soil and is placed under the same cropping system. Corn and small grains are well adapted to this soil.

Judson silt loam.—Judson silt loam occurs in narrow bands at the bases of slopes within the silty soil section of the county. In general it lies between the upland and the other terrace soils. It consists mainly of material washed from the ridges and slopes and collected at the base of the hill. There is little or no difference in texture between the surface soil and subsoil, but the subsoil may be lighter in color than the surface soil. Judson silt loam is regarded as a very fertile soil, and wherever it is possible to cultivate it high crop yields are obtained. Corn is grown almost continuously without noticeable harmful effect to the fertility of the soil. This, no doubt, is owing to the frequent deposition of new material from the uplands during each hard rain, causing the enrichment of this soil at the expense of the uplands. Crop yields are always higher than those obtained on the thin upland soils in this section of the county.

Bremer silt loam.—Bremer silt loam is one of the most extensively developed terrace soils in the county. It is mapped on low terraces from 4 to 8 feet above the present flood plains of the rivers. The surface soil is very dark brown or almost black silt loam to a depth of 12 or 15 inches. The surface layer is very high in humus content and, therefore, very dark in color. Below a depth of 12 inches the soil mass becomes heavier in texture and the dark color begins to disappear. At a depth of about 24 inches the subsoil is dark grayish-brown or gray, streaked with brown, rust brown, and black, heavy sticky silty clay loam. Many small pockets of sandy and gravelly material occur in the subsoil below a depth of 50 inches.

The surface relief of Bremer silt loam is level or slightly sloping toward the stream. Natural drainage ranges from good in the smaller developments to poor in the larger areas.

Practically all of this soil is used for the production of corn. The fields are level, naturally fertile, and withstand heavy cropping without noticeable damage. Many of the terraces have been continuously cropped to corn for 20 years with but little lowering of the yields. Crop yields compare favorably with those obtained on Tama silt loam and Carrington loam. Yields are lower in wet seasons, however, than in years when the rainfall is normal or slightly below the average.

O'Neill loam.—O'Neill loam is one of the principal terrace soils of Guthrie County. It occurs along all the streams within the glaciated

area, on high benches from 10 to 15 feet above overflow. The areas are level, but, as the subsoils are gravelly, natural drainage ranges from good to excessive. The surface soil is dark grayish-brown friable loam about 12 inches thick. It rests on yellowish-brown gritty or sandy clay loam. At a depth of about 24 inches, the heavy layer is abruptly underlain by a layer of loose stratified sand and gravel.

A few small areas, in which the soil is not typical of the O'Neill series, have been included with O'Neill loam in mapping. The subsoil is calcareous in reaction, and in a few places the gravelly layer is not present above a depth of about 30 inches. This variation is a better soil than typical O'Neill loam, because it is less droughty and better adapted to all the farm crops commonly grown.

O'Neill fine sandy loam.—O'Neill fine sandy loam is very similar to O'Neill loam, differing only in the lighter texture of the surface soil and the thickness of the dark layer. In seasons of normal or excessive rainfall, crop yields are fair, but in dry seasons crops fire badly and yields are far below those obtained on the better upland soils. Small grains are better adapted to the O'Neill soils, because they generally mature before the drought period occurs and therefore suffer less damage through firing than does corn. In normal years corn yields average between 35 and 40 bushels an acre, and in dry seasons the average yield is often lowered to 15 or 20 bushels.

SOILS USED FOR GRAIN AND PASTURE

The grain and pasture soils of Guthrie County include both those soils which can not be cropped regularly and those which may be cropped on one farm but in some other locality must be used as hay or pasture land on account of certain factors, such as unfavorable surface relief and drainage. The members of this group are Shelby loam, Clinton silt loam, Tama silt loam, shallow phase, Clarion fine sandy loam, Dickinson fine sandy loam, Bremer silty clay loam, Fargo silty clay loam, and Wabash silt loam, colluvial phase.

Shelby loam.—Shelby loam is one of the most extensive soils in that part of the county west and south of Middle Raccoon River. It is mapped on the slopes adjacent to practically all the streams and their tributaries within this section of the county. It has been derived from material laid down by the Kansan ice sheet and exposed after the removal of the silty layer by erosion. The surface soil in places is modified by wind-blown silty material, but in most places the silt has been entirely washed from the slopes, exposing the gritty drift material.

The surface soil of Shelby loam is dark grayish-brown mellow loam ranging in thickness from a very thin layer to 8 inches, depending on the steepness of the slope. The upper part of the subsoil to a depth of about 11 inches is brown or grayish-brown rather gritty loam or sandy loam. The lower part of the subsoil may be yellowish-brown, streaked with gray, white, and rust brown, or may be reddish-brown gritty clay loam. Bowlders of different sizes are embedded throughout the subsoil.

Shelby loam varies greatly in the texture of the surface layer. The texture of the material on the upper part of the slope is generally

silty, being a thin layer of loess over the drift; at the middle of the slope the material contains more sand; and at the base of the slope it is very sandy in texture. The variation in texture is not consistent, therefore it is impossible to make further separations, and all this kind of soil is included with Shelby loam. The variable depth of the surface covering is readily noticeable in plowed fields. On many of the sharp crests of the ridges the material is yellowish brown or reddish brown. Here the dark surface layer has been completely eroded and the subsoil exposed. Small gullies quickly form when the steep slopes are plowed and planted to cultivated crops.

Shelby loam mapped along the north bank of South Raccoon River is different from the rest of the soil mapped in the county. Here the surface soil is very thin, the subsoil is reddish brown, and the texture is sandy and gravelly. Large rust-brown iron concretions, many filled with fine sand, lie on the surface or are embedded in the lower layers.

The surface relief of Shelby loam ranges from strongly rolling to hilly. Natural drainage ranges from good to excessive, and the rapid run-off of water causes serious damage to the fields. The slopes are steep, and therefore a large part of the area occupied by this soil can not be cultivated. In Bear Grove, Baker, Grant, and Thompson Townships, Shelby loam has a deeper surface soil and the slopes are not so steep as in the areas of stronger relief. Here the greater part of this soil can be cultivated if care is taken not to keep it under cultivation for a number of years. Less than one-half of the total area of Shelby loam within the county is under cultivation. Many fields formerly cropped have been allowed to revert to grass pastures after the dark surface material has been washed away. A large part of the uncultivable Shelby loam is forested with oak, plum, elm, and haw trees, and other slopes are thickly covered with hazel brush and buck brush. Old pastures are very weedy and furnish very little feed for livestock. In recent years, trees have encroached on a large part of the slopes along the streams.

Shelby loam is not regarded as a good corn soil. When the fields are plowed danger of damage by erosion is great. When the fields are plowed because the grass is being crowded out by weeds and brush, corn is planted but one year and the fields are then seeded to small grain which serves as a nurse crop for the mixed clover and timothy hay. Hay is cut from the meadows for one or two years, after which the land is pastured until it is necessary to plow it in order to destroy the weeds. That part of Shelby loam too steep to cultivate remains in bluegrass pasture all the time, but some of the pastures are so thin and weedy that some means should be taken to improve them. By disking and reseeding the old pastures their feeding value could be greatly increased. In many places, liming and fertilization would be a benefit.

Clinton silt loam.—Clinton silt loam is locally called "white oak" or "hickory" soil. It was thickly forested with oaks and hickory long before white settlers entered the county. This soil is mapped in small areas along the larger streams and their tributaries in the loess-covered part of the county. Clinton silt loam was one of the first soils occupied by the early settlers, mainly because of the timber

growth and the nearness to a water supply. More than one-half of the total area of this soil has been cleared and placed under the plow. In many places the cleared areas have become badly eroded and gullied and later allowed to revert to bluegrass pasture and forest. The narrow ridge tops are kept under cultivation, with hay and small grains as the chief crops grown.

Clinton silt loam has a grayish-brown or gray friable smooth silt loam surface soil to a depth of 7 or 9 inches. Below this the color of the gray material changes to more yellowish brown or yellowish gray, and the texture becomes somewhat heavier. Below a depth of 15 inches the material is very compact stiff plastic yellowish-brown clay loam which is decidedly heavier in texture than the material in either of the overlying layers. The lower part of the subsoil, below a depth of 40 inches, is mottled gray, brown, and yellow silty clay loam stained with rust-brown and black iron oxides.

Tama silt loam, shallow phase.—Tama silt loam, shallow phase, differs from typical Tama silt loam mainly in the depth of the dark surface layer. It is extensively developed in the silt-covered section of the county and occurs on practically all the strongly rolling plains and narrow ridges, from which not all the silty material has been removed and the drift material is exposed or near the surface, thereby affecting the soil texture. The surface soil is light-brown or brown friable smooth silt loam to a depth not exceeding 6 inches. Below this the color becomes more yellowish brown, and at a depth of about 10 inches the texture changes to silty clay loam. The lower part of the subsoil is not materially different from the corresponding layer of typical Tama silt loam.

The surface relief of Tama silt loam, shallow phase, is strongly rolling or almost hilly. The slopes are steep and the ridges narrow. A small proportion of the land is covered by a dense growth of hazel brush, buck brush, and a few scattered trees, mainly plum, scrub oak, and elm.

All of Tama silt loam, shallow phase, is not suitable for cropping. The more gentle slopes are cultivated for short periods, and the remainder is used either as hay land or for pasture. The method of cropping consists of planting one crop of corn on sod land and the following season sowing a small grain in which the hay mixture is seeded. This soil is very well adapted to hay crops. Excellent stands are obtained, the yields are heavy, and the covering of grass prevents sheet washing and gullying of the slopes.

This shallow soil requires care in handling and should not be cropped any more than is necessary to prevent weeds from overrunning the fields. Many fields are so severely eroded that the yellow subsoil is exposed. Such areas could be greatly improved by heavy applications of manure and the plowing under of green manure when it becomes necessary to break the sod in order to kill the weeds. Contour plowing and terracing of many of the slopes would prevent washing and gullying Much of this land could be placed under the plow and be made to produce good crop yields if these recommendations were followed.

Clarion fine sandy loam.—The 8 or 10 inch surface soil of Clarion fine sandy loam is dark-brown loose fine sandy loam. It is underlain by a yellowish-brown and pale-yellow subsoil. The textures

of both the surface soil and subsoil are variable, ranging, within short distances, from sand to fine sand in the surface soil and from gritty clay to sandy clay loam in the subsoil. This soil occurs within Clarion loam areas, occupying the high knolls or long narrow ridges near the larger drainage courses. The areas are small, and, as no farm is made up entirely of this soil, it is cultivated with the adjoining soils and receives the same treatment.

The light sandy surface soil is not so retentive of moisture as are the surface soils of the heavier soils, and crops often suffer from lack of moisture during periods of drought. These sandy areas should receive more attention than the heavier soils because they are deficient in organic matter. With an added amount of humus this soil could retain more moisture and deliver it to the crops when it is most needed. Clarion fine sandy loam is better adapted to small-grain and hay production than to corn, because of its droughtiness. Early-maturing crops are harvested before the dry periods in July and August.

Dickinson fine sandy loam.—Dickinson fine sandy loam is agriculturally the least desirable upland soil in the northeastern part of the county. Very little difference is noted in the texture of the soil material from the surface downward, but the color changes from brown in the surface soil to yellowish brown in the subsoil. This soil is very droughty, and it requires special care in handling and the incorporation of large quantities of organic matter in order to prevent crops from firing, even in years of normal rainfall. The total acreage in the county is small. By making heavy applications of barnyard manure and plowing under green-manure crops, the humus content can be maintained and the moisture-holding capacity of the soil increased to such an extent that crop yields will not be materially affected because of lack of moisture.

The sandy texture of Dickinson fine sandy loam makes it especially adapted to the production of truck crops. It warms up early in the spring, is easily cultivated, and responds well to manurial treatment. Melon growing should be profitable if a market for the product is obtained. Deep-rooted legumes, such as sweetclover and alfalfa, do well on this soil. Much of the land is acid and must be limed before these legumes can be grown successfully, but once they are established they will furnish good hay or pasture for all kinds of livestock.

Bremer silty clay loam.—Bremer silty clay loam, together with other terrace soils, occurs on low terraces from 3 to 6 feet above the present flood plains of the rivers. It occupies depressions within areas of better-drained soils or low areas farthest from the stream channel. The surface soil is very dark grayish-brown (black when wet) sticky silty clay loam. In many places the dark color extends to a depth of 15 or 18 inches The humus content is very high. Below a depth of 20 inches the subsoil is dark grayish-brown or gray heavy silty clay loam or clay, in which streaks of brown, rust brown, and black give the material a mottled appearance.

Bremer silty clay loam is naturally poorly drained, and unless some means are provided to carry off the surplus water the soil can not

be successfully cropped. Open ditches are used to drain much of this land, and, where necessary, tiles are laid through the lower spots to supply adequate drainage under all seasonal conditions. The drained areas of Bremer silty clay loam are almost continuously cropped to corn, as small grains tend to produce a rank growth and lodge badly. Crop yields on the well-drained areas compare favorably with those on the other dark-colored naturally fertile soils of the county. The undrained areas support a rank growth of slough grass which serves as coarse winter roughage, when cured, and as pasture grass during the grazing season.

Fargo silty clay loam.—Fargo silty clay loam is mapped on low flat poorly drained terraces along Mosquito Creek and Bays Branch, and near old lake beds within the late Wisconsin drift area. The surface soil, which is very dark grayish brown when dry and almost black when wet, consists of heavy sticky silty clay loam. Numerous small shells are scattered over the surface and through the surface material to a depth of 4 inches. The humus content is extremely high in the upper 20 inches of the profile. The lower subsoil layer is gray or light-gray silty clay or clay. Streaks of lime are abundant in the subsoil. The material throughout the entire profile is calcareous in reaction, and in this characteristic the soil differs from Bremer silty clay loam.

Fargo silty clay loam requires artificial drainage to make it productive. When the land is thoroughly drained, corn is the principal crop grown. Corn yields range from 30 to 75 bushels an acre, depending on seasonal conditions and thoroughness of the drainage. The undrained areas are used as pasture land. A rank growth of slough grass covers these wet areas, and, if conditions allow cutting and curing, this grass is used as winter roughage.

Wabash silt loam, colluvial phase.—Wabash silt loam, colluvial phase, is mapped at the bases of slopes and in the U-shaped valleys of the stream tributaries extending into the loessial upland area of the county. The surface soil is very dark brown heavy silt loam or light silty clay loam to a depth ranging from 24 to 30 inches. The subsoil is dark-brown or grayish-brown silty clay loam or clay loam. The dark organic coloring is present at a depth ranging from 4 to 5 feet. This soil is composed of material washed from the silty slopes of the upland and accumulated in the valleys. The land is naturally very fertile, and if drainage is adequate it is farmed in conjunction with the upland soils. Some of the areas are artificially drained, but the majority of them are farmed in their natural state. Crop yields are higher on areas of this soil than on the eroded slopes, and it is of great advantage to crop them wherever possible. No special care is given this phase of Wabash silt loam to make it more productive. Corn is better adapted to it than are the small grains, because the latter are apt to lodge badly in this fertile soil.

SOILS USED FOR PASTURE

The soils included in the third group are those suitable only for pasture. Both upland and bottom-land soils are included, the upland soils because the areas are too hilly to cultivate or because

they support a forest growth, and the bottom-land soils because their proximity to streams results in frequent overflow during the growing season. The upland members of this pasture group are Clarion loam, steep phase, Lindley loam, and Crawford loam, and the bottom-land members are Wabash silt loam, Wabash loam, and Wabash silty clay loam. The miscellaneous classification, peat and muck, is also included.

Clarion loam, steep phase.—Clarion loam, steep phase, is a soil of small extent in Guthrie County. It is mapped on the steep slopes adjacent to the larger streams in the Wisconsin drift area. Erosion has been active, and practically all the dark surface material has been removed, so that the pale-yellow calcareous subsoil either is exposed or is covered by only a few inches of dark-brown surface soil. The texture of both the surface soil and subsoil is variable. The surface soil may range from loam to gravelly loam and the subsoil from sandy clay loam to almost gravel within a short distance.

The areas of this soil are not farmed but remain in pasture continuously. They support a growth of bluegrass, bluestem, and various pasture weeds. During dry periods in July and August the grasses almost completely die out, owing to lack of moisture.

Lindley loam.—Lindley loam is one of the few forested soils in the county. It is mapped in the rougher sections along the master streams. The tree growth, consisting of oak, elm, hickory, walnut, butternut, basswood, and plum, is so dense that the grass undercover can not thrive.

The surface soil is gray or brownish-gray friable loam, in few places exceeding 4 inches in thickness. The subsoil is yellowish-brown sandy or gritty clay loam, in many places containing some lime carbonate.

Only a very few small isolated areas on ridge tops have been cleared and cropped to small grain and hay, and the remainder of the soil is used as pasture land. As the dense stand of trees prevents the growth of grasses, land of this kind is of little value except for timber. The slopes are so steep that the timber can be cut and removed only with difficulty. Lindley loam is one of the least desirable soils of Guthrie County.

Crawford loam.—Crawford loam is a soil weathered from a combination of drift material and residual material derived from limestone rock. The surface relief is very hilly or broken, and natural drainage is excessive. Only a few small areas are mapped along Middle Raccoon River in Jackson Township and along South Raccoon River in Penn Township. The surface soil to a depth of 6 or 8 inches is brown or dark-brown loam. This rests on reddish-brown heavy waxy compact clay which in turn rests on the limestone bedrock. The rock outcrops at the bases of all the slopes.

Crawford loam is unimportant agriculturally. None of it is cultivated, and it is of little value as pasture land. It supports a growth of trees and a dense growth of underbrush. The slopes are so steep that livestock find it difficult to graze the areas. Sheep and goats are sometimes used to keep down the scrub oak and brush, which quickly invade the slopes.

Wabash silt loam.—Wabash silt loam is the most extensively developed first-bottom soil within the county. It occurs along practically all the streams, the width of the flood plain depending largely on the size of the stream. This soil is subject to frequent overflow unless protected by dikes or levees.

The surface soil is very dark grayish-brown silt loam, and the subsoil is gray or slate-colored heavy silty clay loam. The surface soil is variable in texture and in the narrow developments may range from loam to silty clay loam within a short distance. In the wide areas the part of the bottom land adjacent to the stream is more sandy than that a short distance from the stream.

Some large areas of Wabash silt loam have been diked to prevent overflow, but most of the soil is used as pasture land. It is one of the best pasture soils in the county Bluegrass grows luxuriantly and affords good feed throughout the grazing season. Even in periods of drought this bottom-land soil contains sufficient moisture to keep the grass growing. A few scattered trees, mainly cottonwood, willow, elm, and ash, furnish shade for the livestock during the hot summer. When this land is cropped, corn is grown exclusively.

Wabash silty clay loam.—Wabash silty clay loam is a bottom-land soil subject to frequent overflow and naturally poorly drained. The most extensive developments are along Bays Branch and Mosquito Creek. The channels of these two streams are very shallow, and in many places the water spreads over a wide area, forming a marshy pond.

The surface soil of Wabash silty clay loam is very dark brown or black sticky silty clay loam to a depth of 18 or 20 inches. This gradually passes into gray sticky impervious clay loam or clay. In most places the soil throughout the entire profile is noncalcareous, but in a few local spots it contains lime in small quantities. This soil supports a heavy growth of slough grass, reeds, and other water-loving plants. The better-drained areas produce a finer grass which is cut and cured for winter roughage, but most of the soil is used as pasture. Some upland soil areas adjacent to these bottoms are pastured in conjunction with them, as livestock do not thrive well on the coarse grasses growing on this wet land.

Wabash loam.—Wabash loam has a mellow loamy surface soil to a depth ranging from 12 to 20 inches. Most of the areas are narrow, and the texture of the material is variable but is in general loam. The subsoil is gray heavy silty clay loam. This soil is subject to frequent overflow and can not be cropped successfully. It supports a good growth of bluegrass which seems to withstand floods and the deposition of new material after each freshet. A few scattered trees and some buck brush have gained a foothold on these bottoms

Peat and muck.—A few small areas of peat and muck occur in secs. 23 and 26, T. 81 N., R. 31 W. They are indicated by swamp symbols. When drained the soil is adapted to several farm crops, but in Guthrie County it is used only for hay and pasture, for which it has a very low value.

RECOMMENDATIONS FOR THE UTILIZATION AND IMPROVEMENT OF GUTHRIE COUNTY SOILS

The Iowa Agricultural Experiment Station has approximately 90 experiment fields located within the State. These fields are under the supervision of field men from the station and are farmed by the owner of the land along with the rest of the farm. Different soil types are selected, plots staked out, and different fertilizer treatments made on these plots by the station field men, and the plowing, planting, and cultivation are done by the farmer. No special care is given the plots other than that received by the rest of the field. Harvesting is done by the station field men and the results recorded. These plots are located in counties in which the soil survey has been completed, consequently no experiment field is located in Guthrie County at the present time. However, an experiment field is located on Tama silt loam in Adair County near Greenfield. The soil in this field is very similar to that mapped in Guthrie County, and the results are indicative of results that may be expected when this soil is treated in the same manner with different fertilizers.

Table 5 records the results obtained from different fertilizer treatments on Tama silt loam over a period of years in different sections of Iowa.

TABLE 5.—*Average crop yields per acre and increases due to fertilizer treatment on Tama silt loam on Iowa experiment fields*[1]

Treatment	Corn[2]		Oats[3]		Hay (clover, timothy and clover, or timothy)[4]	
	Average yield	Increase for treatment	Average yield	Increase for treatment	Average yield	Increase for treatment
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Tons*	*Tons*
Check[5]	53 9		55 2		1 51	
Manure	58 3	4 4	58 6	3 4	1 59	0.08
Manure+lime	60 6	6 7	63 3	8 1	1 69	18
Manure+lime+rock phosphate	60 8	6 9	69 3	14 1	1 85	.34
Manure+lime+superphosphate	62 2	8 3	67.4	12 2	1 91	.40
Manure+lime+superphosphate+potassium	61. 1	7 2	72 6	17.4	1 95	.44
Manure+lime+complete commercial fertilizer	62 3	8 4	71 0	15 8	1 84	.33
Crop residues	55 3	1.4	53 6		1.46	
Crop residues+lime	62 7	8 8	61 6	6 4	1.97	.46
Crop residues+lime+rock phosphate	66 6	12 7	61 4	6.2	2 01	.50
Crop residues+lime+superphosphate	65 2	11 3	60 4	5 2	2.08	.57
Crop residues+lime+complete commercial fertilizer	64 4	10 5	63 4	8 2	2 28	.77

[1] Data from State Soil Survey of Iowa

[2] Corn yields averaged from 27 crops on 7 fields, except the manure+lime+superphosphate+potassium plot which is averaged from 22 crops on 6 fields, and the crop-residue plots which were averaged from 5 crops on 1 field

[3] Oat yields averaged from 11 crops on 7 fields, except the manure+lime+superphosphate+potassium plot which is averaged from 8 crops on 6 fields, and the crop-residue plots which are averaged from 3 crops on 1 field.

[4] Hay yields averaged from 6 crops on 4 fields, except the manure+lime+superphosphate+potassium plot which is averaged from 4 crops on 3 fields, and the crop-residue plots which are averaged from 2 crops on 1 field

[5] The yields given for the checks are the averages of the yields on all check plots on all fields

The soils in the northeastern part of the county are similar to the soils in Dallas County. An experiment field is located on Car-

rington loam, near Dallas Center, and seven years' results from this field are given in Table 6.

TABLE 6.—*Acre yields from Dallas Center field on Carrington loam in Dallas County, Iowa*[1]

Plot No.	Treatment	Winter wheat, 1923	Clover, 1924[2]	Corn		Oats, 1927	Sweet-clover, 1928[3]	Corn, 1929[4]
				1925	1926			
		Bushels		*Bushels*	*Bushels*	*Bushels*	*Tons*	*Bushels*
1	Check	24 8		50 3	69 9	52. 6	1 81	69 0
2	Manure	25 9		51 2	73. 0	51 7	2. 00	75 4
3	Manure, limestone	29 6		54 1	78 9	50 2	1 97	79 2
4	Manure, limestone, rock phosphate	30 9		58. 8	79 2	68. 2	2. 29	78. 3
5	Check	21 8		51 9	76 0	53 4	1 78	69 1
6	Manure, limestone, superphosphate	33 8		58. 8	76 8	64 3	2 42	82. 2
7	Manure, limestone, superphosphate, potassium	34 5		59 6	78. 9	62. 4	2. 17	80. 4
8	Manure, limestone, complete commercial fertilizer	30 4		59 5	73. 6	64 4	2. 69	80 2
9	Check	20. 6		53. 3	65. 3	46 3	1 65	74. 1

[1] Data from State Soil Survey of Iowa
[2] Field was pastured, no results
[3] Total of two cuttings
[4] Yield on 15 per cent moisture basis

Detailed information on these experiment fields may be obtained from the Iowa Agricultural Experiment Station Bulletins 212, 221, and 269, obtainable through the soils department or bulletin section of Iowa State College at Ames.

Under the present cropping systems and farm-management practices, very few farm operators are building up the fertility of their soils. Many fields are being cropped that should never be plowed, as erosion, such as gullying and sheet wash, removes more plant food from the soils annually than is used by the crops. Fields, which once had deep dark-colored surface soils, have been cultivated so often that practically all the surface material has been removed and the yellowish-brown or reddish-brown subsoil is exposed. By adopting a system of cropping and by terracing the more gentle slopes, these thin soils may be restored to a moderately high state of fertility. Some of the hillsides, however, have been damaged so badly that it would be economically unsound to attempt to place them on a crop-producing basis. The ridges and gentle slopes represent the land to be considered in the soil-building programs. The steeper slopes and eroded hillsides can best be used as pasture land. Disking and reseeding these hills would improve their value as grazing land, and the thicker stand of grass would keep weeds from obtaining possession of the land.

Corn is the dominant crop, and the tendency is to grow it as often as and wherever possible, regardless of the detrimental effect on the soil. After a series of years of corn and small-grain cropping, yields diminish, and then something is generally done to restore the fertility of the soil. The better plan is to avoid reaching the low fertility level by following a systematic cropping plan which includes some legume. The legume may be red clover, or, if the soils are sweet or

have been limed if sour, sweetclover or alfalfa can be seeded. The first crop of hay may be removed, but the second crop should be plowed under. Some farmers pasture the second crop and plow under the clover the following spring. If the soil is very thin it is advisable to allow the first cutting to remain on the fields and to plow under the entire crop. All tillable soils should be cropped systematically, with the thought in mind that the fertility should not only be maintained but that the soil should be built up yearly in its producing power. Land which will produce 70 bushels of corn an acre is much more valuable than land which will produce only 35 bushels. In producing 70 bushels of corn the average cost is about 35 cents a bushel, whereas yields of 35 bushels are produced at a cost of about 70 cents a bushel. If the operator be a grain farmer, the 70-bushel yields are grown at a profit and the 35-bushel yields will just about pay the cost of production. Cattle and hog feeders stand a much better chance to make a profit when feeding 35-cent corn than when the cost of producing each bushel reaches 70 cents.

Commercial fertilizers are being tried on a small scale in several localities. Their use should be limited to fields from which economical returns can be assured. Small test plots or strips through the field will show whether or not it would be profitable to fertilize the whole field. Liming is essential for the successful growing of alfalfa and sweetclover if the soils are acid.

Within the boundaries of Guthrie County are hundreds of acres of grass or pasture land, much of which is overgrazed. Weeds and brush infest many of the hillsides, crowding out the bluegrass and lowering the pasture value. These weeds should be destroyed wherever possible, and fewer cattle should be allowed in the pastures. Sheep and goats are excellent weed and brush eradicators. The Iowa Agricultural Experiment Station has been conducting work on pasture improvement within the State. On one field, located on a soil similar to the majority of the pasture land in Guthrie County, several different treatments have been tried in a study of the effect on the growth of pasture grasses. Among the different treatments are disking, disking and reseeding, liming and disking, liming together with disking and reseeding, and the use of nitrate fertilizers. Results indicate that disking and reseeding with a mixture of red clover, timothy, and alsike clover will materially benefit old pastures. Disking and reseeding are done in the early spring. The pastures are double disked in the same direction each time with the disk set straight so that the sod will not be turned. Cross disking cuts the sod into small squares and therefore is not recommended. If the pasture soil is sweet (lime present), alfalfa and sweetclover should be included in the grass mixture. Some means should be taken to prevent weeds, brush, and trees from invading the pastures.

Additional increases in crop yields could be obtained by taking advantage of the new varieties of corn and small grains developed by the Iowa station staff. Some of the new varieties are especially adapted to Guthrie County. It has been shown that many of the corn hybrids outyield the best purebred strains by several bushels an acre. The oat varieties best adapted are Iogold which is an early oat, Iogren which should replace Green Russian, and Iowar which is a very good yielder. Iobred and Kanred wheat are very good

yielders, stiff strawed, and somewhat rust resistant. The new Trebi barley outyields all other varieties common to Iowa.

SOILS AND THEIR RELATIONSHIPS

Guthrie County lies within the prairie region of the United States. Temperature and moisture conditions were favorable for the luxuriant growth of prairie grasses, and the development of the soils proceeded under this cover. Grass roots, penetrating deeply into the soil, decayed and became an integral part of the upper soil layer. As the supply of organic matter increased, the color of the surface layer became darker, and now ranges from dark grayish brown to almost black. The depth of the dark layer ranges from 4 to 22 inches, depending on the surface relief and drainage. Under good drainage conditions, as occur in the rolling and hilly sections, oxidation of the organic matter was more rapid, because of better aeration of the soil, than in the areas where the soils were moist and under water at least part of the year. Under the wet condition, decomposition of the organic matter was retarded, and therefore greater quantities of vegetable material accumulated. All the naturally wet soils of the county are extremely dark in color, grayish brown or black when dry and intensely black when wet.

The soils in Guthrie County have developed from two principal materials. The line dividing the late Wisconsin drift area from the southern Iowa loess area follows approximately the east bank of Middle Raccoon River, so that the glaciated area comprises about one-fourth of the county. The surface relief of the glaciated area is level or undulating, with the exception of the narrow eroded band near the river. These soils contain more or less sand, and bowlders are scattered over the surface or are embedded in the lower layers. Lime is abundant in the subsoils.

The typical loess west of the river is composed of silty material containing a small percentage of sand, insufficient to influence greatly the soil texture. This mantle of loess differs in thickness according to the surface relief. Where it is entirely removed, as on steep slopes, the underlying Kansan drift is exposed. The surface relief of the loessial area ranges from level on the broad divides to hilly or broken near the larger streams.

The different soils of Guthrie County have been grouped into soil series on the basis of the origin of the parent material and on the chemical composition, color, depth, and structural characteristics of the different soil horizons. Seventeen soil series have been recognized in the county. These series have been further divided, on the basis of the texture of the surface soil, into 23 soil types and 3 phases of types.

The soils of Guthrie County may be placed in two major groups on the basis of the drainage conditions under which they have developed. The first group includes those soils formed under good drainage conditions, which are regarded as normally developed soils; and the second group includes the soils developed under poor drainage which retarded normal development or produced an abnormal development.

The normally developed soils occur only in rolling upland areas where surface and subsoil drainage are well established, where the

weathering processes have continued uninterrupted except for seasonal changes, and where the precipitation normally occurring for this area was sufficient to support plant life throughout the growing season.

Under these conditions of rainfall, drainage, and temperature, the weathering processes developed a mature or almost mature soil profile. The upper layer is very dark grayish-brown faintly granular material, ranging from 8 to 16 inches in thickness, filled with organic matter and partly decomposed plant remains. In virgin areas the upper 2 or 3 inches of this layer is a turf held together by a mat of grass roots. Faint lamination is noticeable in many places in this upper layer. Beneath the dark surface is a transitional zone, the upper part of which is brown, grading into yellowish brown in the lower part. The texture of this transitional layer is decidedly heavier than that of the surface layer. The dark color is caused by the infiltration of organic material from the overlying layer through old root channels, soil cleavage lines, and worm and animal burrows. The dark color is more intense in the upper part and gradually diminishes with depth. The soil granules making up the mass are not dark colored throughout but are merely coated with dark material, and on crushing, the color changes from brown to yellowish brown. Granulation, in the profiles of most of the mature soils, is markedly developed in this transitional horizon. It is more pronounced in the upper part and begins to disappear at a depth ranging from 12 to 20 inches. When the lower part of the soil mass comprising this layer is disturbed, it breaks down into irregular-shaped soft clods which are coated with dark material. The third horizon consists of the parent material which is silty in texture and only slightly modified by weathering. The color ranges from gray, brown, or yellow, in the loess of the western part of the county, to yellow or grayish yellow in the late Wisconsin drift of the northeastern part.

The drift material is leached to a depth ranging from 20 to 50 inches. Where the surface relief is favorable for erosional action, the washing away of the upper layers is more rapid than leaching, and lime occurs closer to the surface. Smooth gentle slopes and broad ridges have been leached of their lime to a depth ranging from 45 to 60 inches. In practically all places within the drift-covered area, lime occurs at a depth of less than 60 inches. In the western part of the county, which is covered by the mantle of loess, leaching has progressed to such an extent that no lime occurs in the parent material to a depth ranging from 10 to 12 feet. The underlying Kansan drift contains streaks of free lime in many places, but no carbonates occur in the loessial material in any part of the county.

Differences in the soil profiles occur throughout the county. Erosional action causes rapid and numerous changes, within short distances, in the thickness of the dark surface layer. Uneroded areas are naturally darker in color and have thicker surface layers.

The most important of the well-drained normally developed soils are Tama silt loam, Marshall silt loam, Carrington loam, and Clarion loam. Other soils included with this group are Tama silt loam, shallow phase, Clinton silt loam, Shelby loam, Lindley loam, Clarion fine sandy loam, Clarion loam, steep phase, Dickinson fine sandy

loam, Crawford loam, Waukesha silt loam, O'Neill loam, and O'Neill fine sandy loam.

Tama silt loam is of loessial origin. Leaching and weathering have progressed to a marked degree. The A horizon varies with the surface relief. The B horizon is not distinctly developed, but the material is decidedly heavier in texture than that in either the A or C layers. No lime occurs at any depth in the profile of Tama silt loam.

Following is a profile description of this soil observed in a roadside cut 3½ miles north of Adair, in Grant Township.

From 0 to 3 inches, the virgin soil is dark grayish-brown friable silt loam containing a small quantity of very fine sand This layer is completely filled with grass roots which cling to the small imperfect soft irregular-shaped granules. The granules appear to be coated with dark-brown material, and when crushed they are lighter brown.

From 3 to 15 inches, dark grayish-brown friable silt loam which is slightly darker than the surface layer. Granulation is distinctly developed in the upper part of this layer and gradually disappears below a depth of 10 inches. The color in the lower part of the layer becomes lighter.

From 15 to 22 inches, a transitional zone, grading from grayish brown to light brown or yellowish brown. The soil mass breaks up into irregular-shaped soft clods which are coated with dark organic material infiltrated from above through soil cleavage lines, root channels, and insect burrows. The crushed mass is yellowish brown.

From 22 to 32 inches, yellowish-brown friable heavy silt loam which readily falls apart into soft clods when disturbed. A few dark organic streaks are evident. The clods, when crushed, are distinctly lighter in color than the material in any of the overlying layers A few rust-brown iron stains and indications of gray color are present, but these are not caused by poor drainage

From 32 to 44 inches, pale yellowish-brown or brown even-textured silt loam splotched and streaked with dark colors where organic matter has penetrated by means of old root channels and small animal burrows. Colorations of gray and rust brown are more noticeable than in the overlying layer, and this staining becomes more pronounced with depth. The soil material has no definite structure and is noncalcareous.

From 44 to 54 inches, mottled gray, brown, and rust-brown structureless silt loam The mottling apparently is not caused by poor drainage This silty mass contains no lime carbonate but does contain a few soft iron concretions. The mass breaks down into large soft clods. Numerous fine needlelike holes are visible on newly broken surfaces.

From 54 to 78 inches, the lower parent material which is a brown silty structureless mass showing less gray, yellowish-brown, and rust-brown mottling and staining than the layers above, but black iron stains are numerous. No carbonates occur at any depth in the profile, showing that leaching has been thorough.

Tama silt loam occupies the gently rolling or rolling uplands in the loessial region west and south of Middle Raccoon River. Drainage is well established and in some places is excessive, causing much damage through sheet washing and gullying.

Occurring as it does on the rolling uplands, Tama silt loam shows many variations in the profile within short distances. Where the ridges are broad and the slopes gentle, the dark surface layer is deep; but as the degree of the slope increases and the ridges become narrow, erosion has removed a part of the dark material and the surface soil is much thinner.

Marshall silt loam is similar to Tama silt loam in appearance. It differs from Tama silt loam in that it contains a small amount of lime. On nearly flat areas, leaching has proceeded to a depth ranging from 3 to 5 feet, but on slopes, where the greater part of this soil

occurs, carbonates are much nearer the surface and in places the surface layer is highly calcareous.

Carrington loam is developed from glacial drift under conditions favorable to deeper leaching. It has reached a stage of development corresponding to that of Tama silt loam. Its profile and principal characteristics are so similar to those of Tama silt loam that it offers little new interest to the soil scientist.

Dickinson fine sandy loam has developed over sandy drift. Its stage of development is about the same as that of Carrington loam. Owing to its sandy texture, the surface soil has not accumulated so large a quantity of organic matter and the color, though well within that of soils of the dark group, is not so black as that of the heavier soils. The surface layers are fine sandy loam, the texture, as a rule, becoming lighter with depth. Below a depth of 18 inches, the material is loose sand containing pockets of coarse sand and gravel in places.

Crawford silt loam is the only residual soil in Guthrie County. The 6-inch surface soil is dark grayish-brown mellow loam which rests on reddish-brown or chocolate-brown waxy greasy compact stiff residual clay, and this, in turn, rests on limestone bedrock at a depth ranging from 24 to 30 inches. The rock outcrops at the bases of the slopes.

Crawford loam is derived from a thin layer of glacial material. and the underlying residual clay. All this soil is forested with oaks, plum, walnut, and basswood, accompanied by an undergrowth of hazel and buck brush.

Clinton silt loam is a light-colored soil developed over loess. It occurs on the forested slopes of hills and ridges in the eroded valleys of the larger streams. The surface soil is grayish brown. The structure is distinctly laminated, and the plates are coated with gray. The subsoil is compact in position and breaks up into nutlike clods. At a depth of less than 3 feet the loess is reached. This soil has developed where a forest growth, consisting of white oak, red oak, and hickory, has spread over eroded slopes.

Lindley loam is a light-colored soil derived from glacial drift. The surface features and vegetation are similar to those of Clinton silt loam. No compact layer is developed as in Clinton silt loam. The parent material below the shallow soil is similar to that of Shelby loam.

O'Neill loam and O'Neill fine sandy loam have surface layers not widely different from that of Waukesha silt loam, but they are underlain by coarse sand or gravel at a depth ranging from 18 to 30 inches. The water-holding capacity of these soils is lower than that of the other well-drained soils of the county.

Shelby loam is developed over the older Kansan drift and probably the Nebraskan drift. It occurs in stream valleys where erosion has carried away the surface deposits of drift and loess and exposed the older material. The dark-colored surface soil varies in thickness from place to place, depending on the degree of slope and the susceptibility of the soil to erosion. In most places, the surface soil is underlain by brown or reddish-brown heavy gravelly clay. At a depth of several feet large quantities of lime remain in the drift material, but, as a rule, the lime has been thoroughly leached from the soil material to a depth of 3 feet.

Waukesha silt loam and Judson silt loam, developed over water-laid materials, have the same general profile as Tama silt loam.

The Clarion soils developed from glacial drift and the Marshall soils developed from loess are separated from the Carrington and the Tama soils on the basis of the depth to which leaching of the carbonates has proceeded. In Clarion loam, carbonates are residual in the subsoil at a depth of less than 3 feet. If that arbitrary depth is exceeded, the soil is correlated with Carrington loam. In this county the areas of these two soils are intermingled, and changes from one to the other occur within short distances. As carbonates occur in Carrington loam in many places at a depth just below 3 feet, this separation does not have great significance or value.

Following is a description of the profile of Clarion loam as observed 1 mile north of Panora

From 0 to 2 inches, very dark grayish-brown very fine sandy loam filled with a mass of grass roots and partly decomposed plant remains

From 2 to 12 inches, very dark brown or dark grayish-brown loam, darker in color and heavier in texture than the surface layer No granulation is developed, but when the mass is disturbed under optimum moisture conditions it breaks down into small soft clods which are dark on the surface and lighter colored in the center

From 12 to 16 inches, a transitional layer of dark yellowish-brown light silty clay loam The material is not uniform in color but is streaked and splotched with dark organic material from the overlying layers

From 16 to 27 inches, dull yellowish-brown sandy clay loam The percentage of sand and small bowlders increases with depth The lower part of this layer contains some lime carbonate Dark organic streaks reach almost through this layer. When crushed the soft clods become lighter brown

From 27 to 46 inches, grayish-yellow or almost yellow structureless heavy fine sandy loam or silt loam The color is uniform, with the exception of a few faint rust-brown stains Lime is evenly disseminated throughout this layer, and small bowlders and fragments of limerock are embedded in the soil mass

From 46 to 60 inches, pale-yellow or pale yellowish-brown fine sandy clay loam somewhat stained with black iron oxide. The texture is not uniform but ranges from sandy clay loam to silt loam or fine sandy loam Streaks of gray and white material, mainly pure lime, are numerous throughout the lower layers

Below a depth of 60 inches, the texture and color of the soil profile does not greatly differ from the material above. Alternate layers of highly calcareous yellow and gray material of various textures make up the unweathered parent material Granitic and limestone bowlders are present in the lower layers.

The profile of Clarion loam observed in other parts of the county does not materially differ from the one described. The slight differences observed are owing to differences in relief which affect the depth of the dark surface layer and the depth at which lime occurs. A few areas occur in which lime is present on the surface or immediately beneath the dark soil layer

Clarion loam is derived from material deposited by the late Wisconsin ice sheet. It occurs only in the undulating and gently rolling uplands in the northeastern part of the county. Natural drainage is well established, the surface relief and the friable subsoil aiding in the escape of surplus water following wet periods.

The soils of the second group occupy flat or depressed areas of the uplands, low flat terraces, and first bottoms, and they have developed under the influence of excessive moisture. These soils have black

finely granular surface layers which in most places are underlain by gray or mottled gray, yellow, and brown subsoils. The details of the profiles of these soils differ considerably, depending to some extent on the character of the parent material, but more on the depth to which drainage and oxidation have extended. Some of these soils were covered by water for only a short period after rains, and others remained continuously under water until artificially drained.

The Webster soils are the most important members of this group. Their surface soils are almost black, deep, and rather heavy in texture. The subsoils are gray and heavily impregnated with lime. Granitic and limestone bowlders are numerous in the subsoils below a depth of 3 feet.

Webster silty clay loam is one of the most extensively developed soils within the Wisconsin drift area in the northeastern part of the county. It is mapped on the poorly drained upland flats, former sloughs, and saucer-shaped basins. Its predominant characteristic is the very dark color of the surface soil.

Following is a description of the profile of typical Webster silty clay loam:

From 0 to 1½ inches, very dark grayish-black silty clay loam containing some fine sand and completely filled with grass roots A faint lamination or platy structure has developed

From 1½ to 10 inches, very dark brown or black silty clay loam, sticky when wet and hard when dry During dry periods large cracks form in the surface layers. The mass breaks down into large clods along old, or former, cracks or possibly along cleavage planes. This layer is strongly calcareous

From 10 to 15 inches, black or grayish-black heavy silty clay or clay, which is very plastic when wet but under optimum moisture conditions readily falls apart into a fine granular mass. Little or no change in color occurs when the granules are crushed

From 15 to 24 inches, dark-gray or grayish-brown silty clay, mottled and stained with light gray and rust brown This layer is composed of large blocks which fall apart into small granules A few small gravel pebbles occur in this layer.

From 24 to 35 inches, the texture changes and the material becomes very silty in the lower part. The color ranges from dark gray to dull gray Small limerocks and lime concretions occur throughout this layer

Below a depth of 35 inches, gray silty unweathered glacial till White lime streaks and iron-oxide stains are numerous. Granitic and limestone bowlders are embedded throughout the unweathered glacial till.

Webster silty clay loam is, in general, very calcareous from the surface downward. A few areas occur in which no carbonates are present in the surface layer or in the subsoil layers to a depth ranging from 20 to 30 inches, but the lower part of the subsoil in all places is calcareous.

Webster loam differs from Webster silty clay loam mainly in the texture of the surface soil. It occupies slightly higher topographic positions In places the upper part of the subsoil is slightly better oxidized than that of the silty clay loam.

Grundy silt loam has developed under better drainage than any other soil of this group. It occurs on the broad, flat divides within the loessial area. The surface soil is dark grayish-brown material, underlain by gray and drab, stained with brown and black, heavy

clay loam. The lower layers show less staining, more gray color, and lighter texture. Leaching has progressed to such an extent that no lime occurs to a depth of 60 inches where the water table is reached.

A number of soils on the first bottoms and low terraces have developed under conditions of restricted drainage. The Bremer and Fargo soils are dense soils, with profiles somewhat similar to those of the Webster and Grundy soils. The Fargo soils are calcareous, but the Bremer soils are low in lime.

The Wabash soils, with the exception of the colluvial phase of Wabash silt loam, occupy the first bottoms.

SUMMARY

Guthrie County lies in west-central Iowa. Guthrie Center, the county seat, is 50 miles west of Des Moines. The county comprises an area of 595 square miles, or 380,800 acres.

Guthrie County is divided into two topographically different parts. The part east of Middle Raccoon River, covering about one-fourth of the county, has the characteristic level or undulating Wisconsin drift area relief, and the rest of the county lies within the southern Iowa loess area, where the surface relief is rolling or broken, with only a few broad level divides between the stream valleys. The slope of the land is to the south and east.

The county was organized in 1851. The early settlers came from the Eastern and Southern States and acquired the forested land near streams. The total population in 1930 was 17,324 persons, all of whom are classed as rural. Guthrie Center, Panora, Stuart, Menlo, and Bayard are the largest towns. Other villages serve as trading centers and loading stations for the farm produce. The Chicago, Milwaukee, St. Paul & Pacific Railroad and the Chicago, Rock Island & Pacific Railway furnish transportation to the Chicago, Omaha, Sioux City, and Des Moines livestock and grain markets.

The climate of Guthrie County is typical of the Corn Belt region. The summers are hot and the winters cold. About two-thirds of the annual rainfall occurs during the growing season. The average length of the frost-free season is 154 days, which is sufficiently long to mature all the general farm crops.

Agriculture is the primary industry. General farming is based on the production of corn. Small grains and hay are produced to supplement corn and to provide winter roughage for livestock. The northeastern part of the county has the largest area of cornland and is regarded as the cash-grain section. The remainder of the county includes a large acreage of pasture and hay land, with only a small acreage suitable for the production of corn. Farmers in this section have naturally adopted the cattle industries. Either dairy or beef cattle are kept, depending on the facilities and individual preferences of the farmers. Hogs are raised on all farms, the number depending on the quantity of available feed.

Most of the labor on farms is supplied by the farmers' families. Extra labor is obtained in the near-by towns and villages.

The soils of Guthrie County may be classed in three groups, on the basis of their value as farming land, as follows: (1) Soils used mainly

for grain, (2) soils used for grain and pasture, and (3) soils used for pasture.

The first group includes those soils of high natural fertility, which are well drained and on which the surface relief allows easy cultivation of large areas. The grain and pasture soils group includes those soils which can not be cropped regularly and those which may be cultivable in one locality and not in another. Some of these soils may be suitable for the production of corn and small grains in one section, and in the adjoining section they must be used as hay or pasture land. These soils occur in the more rolling parts of the county, where erosion is more or less active when the fields are cultivated for extended periods. The third group of soils includes soils suitable only for pasture. Soils occurring in the hilly sections of the county, which are too steep to cultivate or are covered with trees, and the bottom-land soils, subject to frequent overflow and therefore not suitable for cropping, comprise this group.

The agriculture of the county is centered around the production of corn which is either sold for cash or fed to livestock. The livestock industries are threefold, namely, dairy farming, beef-cattle feeding, and hog raising.

The soils of Guthrie County may be greatly improved if the recommendations made by the Iowa Agricultural Experiment Station are followed. By rotating crops, manuring, liming the acid soils, establishing good drainage, growing legumes, and by the judicious use of fertilizers, crop yields can be materially increased.

The soils of the county have been classed in series on their various profile characteristics, and further divided into soil types on the basis of the texture of the surface soil. Seventeen soil series, including 23 soil types and 3 phases of types, are mapped in the county.

The dark-colored well-drained upland soils are represented by members of the Carrington, Clarion, Dickinson, and Shelby series developed over glacial drift, by members of the Tama series developed over loess, and by members of the Crawford series developed over limestone. The well-drained dark-colored terrace soils comprise the members of the Waukesha, O'Neill, and Judson series.

The Webster, Grundy, Bremer, Fargo, and Wabash soils have developed under excessive moisture conditions. The Webster soils are derived from glacial drift, the Grundy soils from loess on flat divides, and the Bremer and Fargo soils occur on low terraces. Wabash soils are first-bottom soils subject to overflow.

The light-colored forested soils are included in the Clinton and Lindley series. Clinton soils are derived from loess and Lindley soils from glacial drift. The soils of both series have developed under a heavy forest cover.

○

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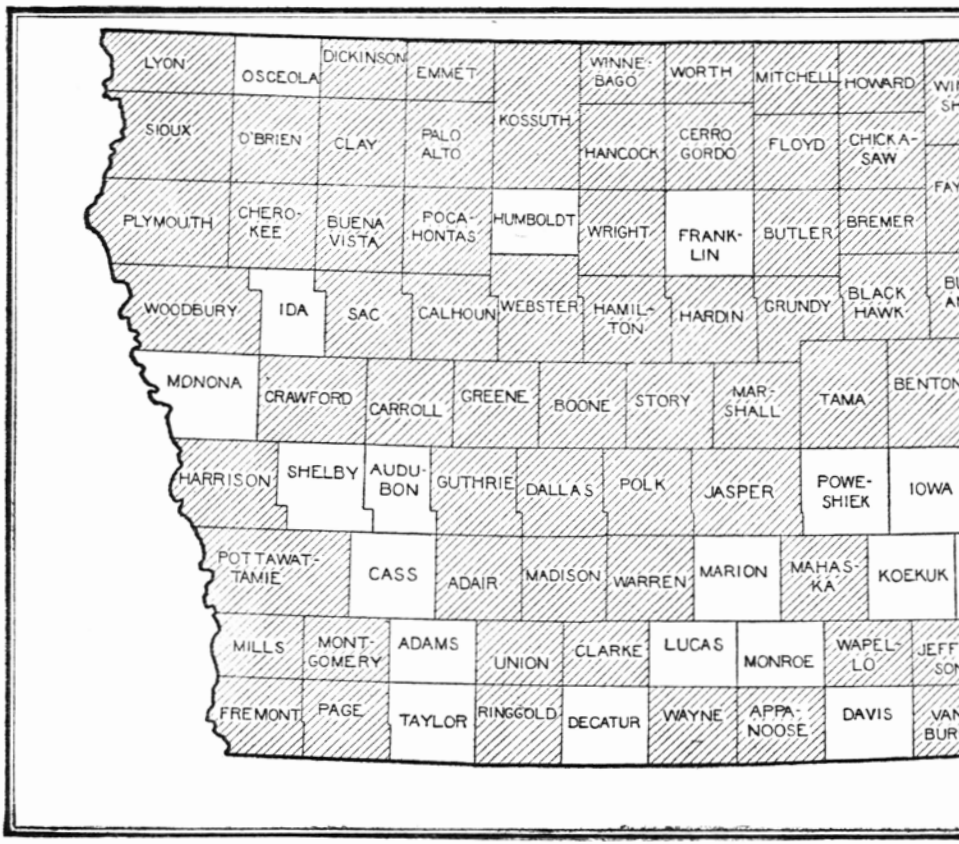
There shall be printed as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than two hundred and fifty copies shall be for the use of each Senator from the State and not more than one thousand copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.



Areas surveyed in Iowa, shown by shading. Detailed surveys shown by north

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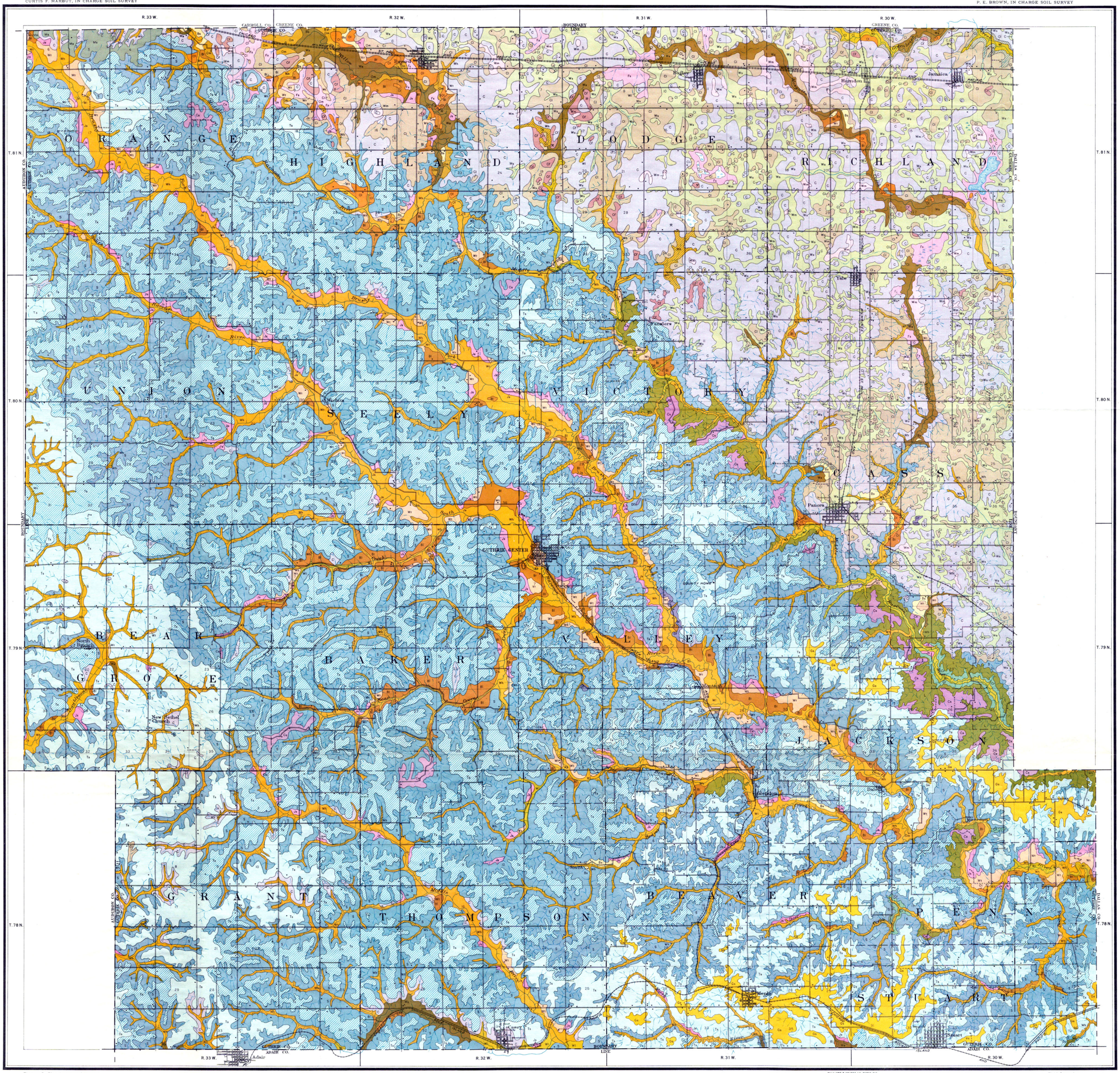
SOIL MAP

GUTHRIE COUNTY
IOWA

IOWA AGRICULTURAL EXPERIMENT STATION
C. F. CURTISS, DIRECTOR
P. E. BROWN, IN CHARGE SOIL SURVEY



LEGEND

- Bremer silt loam — Bl
- Marshall silt loam — Ms
- Bremer silty clay loam — Bs
- O'Neill fine sandy loam — Om
- Carrington loam — C
- O'Neill loam — Ol
- Clarion fine sandy loam — Cf
- Shelby loam — S
- Clarion loam — Cl
- Tama silt loam — Ts
- Cf — Steep phase
- Ts — Shallow phase
- Clinton silt loam — Cs
- Wabash loam — Wl
- Crawford loam — Cr
- Wabash silt loam — Wh
- Dickinson fine sandy loam — Df
- Wh — Colluvial phase
- Fargo silty clay loam — Fs
- Wabash silty clay loam — Wa
- Grundy silt loam — Gs
- Waukesha silt loam — Wt
- Judson silt loam — Js
- Webster loam — Wm
- Lindley loam — L
- Webster silty clay loam — Ws
- Peat and Muck

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

- City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort
- Secondary roads and Trails
- Railroads Steam and Electric
- Bridges, Ferry
- R.R. crossings, Tunnel
- Ford, Dam
- School or Church, Cemeteries
- Mine or Quarry, Mine dumps, Made land
- Bluff, Escarpment, Rock outcrop and Triangulation station
- Stony and Gravelly areas
- Soil boundaries
- Boundary lines
- Boundary lines
- Boundary lines
- U.S. township and section lines

RELIEF
(Printed in brown or black)

- Contours, Depression contours
- Prominent Hills, Mountain Peaks
- Sand Wash, and Sand dunes
- Shore and Low water line, Sandbar

DRAINAGE
(Printed in blue)

- Streams
- Lakes, Ponds, Intermittent lakes
- Intermittent streams
- Springs, Canals and Ditches, Flumes
- Swamp, Salt marshes
- Submerged marsh, Tidal flats

The above signs are in current use on the soil maps. Variations from this usage appear in some maps of earlier dates.

Thomas D. Rice, Inspector, District 3.
Soils surveyed by C. L. Orrben, in charge, and A. M. O'Neal, Iowa Agricultural Experiment Station, and A. H. Hasty and W. C. Boatright, U. S. Department of Agriculture.

Scale 1 inch = 1 mile
1 ½ 0 1 2 3 4 Miles

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Field Operations
Bureau of Chemistry and Soils
1929